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'DUROV PLOT' USERS GUIDE: COMPUTER CALCULATION PLOTTING OF DUROV DIAGRAMS FOR WATER CHEMISTRY ANALYSIS USING THE IBM-AT

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MICROMEDIA

'DUROV PLOT' USERS GUIDE: COMPUTER CALCULATION AND PLOTTING OF DUROV DIAGRAMS FOR WATER CHEMISTRY ANALYSIS USING THE IBM-AT

by

D. Zinck* and T.R.C. Aston**

SUMMARY

The Durov trilinear plot is a method for determining changes in ground/surface water chemistry. This report describes the program 'DUROV PLOT' which undertakes the calculation and plotting of Durov diagrams. The program is written in BASIC A Version 3.10 for an IBM-AT.

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GUIDE DE L'UTILISATEUR DU "RELEVÉ DUROV": CALCUL AUTOMATISÉ ET TRACÉ DES DIAGRAMMES DUROV POUR L'ANALYSE CHIMIQUE DE L'EAU AU MOYEN DE L'ORDINATEUR IBM-AT

par

D. Zinck* et T.R.C. Aston**

RÉSUMÉ

Le relevé trilinéaire de Durov est une méthode servant à déterminer les changements qui surviennent dans la chimie des eaux souterraines et superficielles. Dans ce rapport, l'auteur présente une description du programme 'RELEVÉ DUROV' lequel indique comment faire le calcul et le tracé des diagrammes Durov. Le programme est écrit en langage Basic A, Version 3,10 pour un ordinateur IBM-AT.

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INTRODUCTION

A number of trilinear/graphical techniques exist for the classification of ground/surface water types, Zaporozec (1). The Durov trilinear diagram allows water samples to be quickly, simply and comprehensively analysed and characterised.

The program 'DUROV PLOT' uses a modified Durov diagram to plot and present in diagrammatic form the type and trends of water chemistry samples. The program is essentially a data handling and plotting package, which greatly simplifies the analysis of water samples using the Durov technique.

To use the program it is necessary to input specific ion concentrations (milligrams/litre) determined from the chemical analysis of the water samples under consideration: sodium, potassium, calcium, magnesium, bicarbonate, sulphate and chloride.

'DUROV PLOT' was written for use on an IBM-AT microcomputer using the IBM language BASIC A Version 3.10. The program is conveniently run using either a 360 kB diskette or hard disk along with an EPSON FX100 Dot Matrix Printer and TAXAN XY Plotter (compatible with the HP7475A). The user is expected to be familiar with the operation of microcomputers and the concept of analysing groundwater samples.

A source listing of the program is given along with examples of the input data and output format.

PROGRAM DESCRIPTION

A source listing of the program is given in Appendix A.

Line No.	
100 - 270	Program Header
280 - 680	Program Preamble
690 - 710	Program Dimension Statements
720 - 1330	Program Main Body
1340 - 1460	Subroutine - Durov Plot
1470 - 1670	- Durov Triangle Construction
1680 - 1710	- Sections Plot

1720 - 1810	- Axis Labels
1820 - 1870	Subroutine - Point Plotting
1880 - 2320	- Data File Search
2330 - 2370	- Solves Search Argument
2380 - 2600	Calculates % Ions and Durov Data Points
2610 - 2930	Prints Data Lines
2940 - 3100	Point by Record Plot
3110 - 3170	Option - Plot Sectioned
3180 - 3240	Prints % Ion Concentration
3250 - 3350	Prints Headlines for % Ion Concentration
3360 - 3440	Counts No. of Lines in Data File
3450 - 3540	Checks for Out of Bounds Column No.
3550 - 3580	TAXAN Plotter Routine
3590 - 3640	Error Routine
3650 - 3690	Press Key Routine

A listing of the TAXAN plotter routine is given in Appendix B, while the 'DUROV PLOT' Data Editor is given in Appendix C.

PROGRAM USE

The current version of 'DUROV PLOT' allows up to 70 data points to be plotted (dimension arrays, lines 690 - 710). However, by altering the dimension statement, several hundred data points can be input and handled by the program. The input data file, Table 1, is created separately and called up by the 'DUROV PLOT' program.

'DUROV PLOT' uses a menu style operating sequence within the program which is user friendly. The main menu, lines 800 - 870 (Appendix A), contains the following options:

SEARCH DATA BY LIMITS
POINT BY RECORD NO. PLOT
ANOTHER DATA FILE
CHAIN TO EDITOR
END SESSION
SERVICE MENU

In addition, a service menu, lines 1000 - 1070 (Appendix A), contains the following options regarding output format:

DUROV PLOT
DATA LINES
PLOT ENLARGEMENT
PERCENT ION CONCENTRATION
MAIN MENU
LOAD ALL FILE DATA TO BUFFER,
CLEAR BUFFER, DUROV PLOT ON PLOTTER

A listing of the % Ion Concentrations obtained from the input data, Table 1, is given in Table 2. The 'DUROV PLOT' (service menu option) giving the location of the points in Table 1 is shown in Figure 1 (EPSON FX100), while the 'DUROV PLOT' enlargement option is shown in Figure 2 (ESPON FX100). The 'DUROV PLOT' (TAXAN Plotter option) is shown in Figure 3.

ACKNOWLEDGEMENTS

A program to undertake the analysis of water chemistry samples using Durov diagrams has already been written in G-BASIC language for the North Star microcomputer (2). The authors would therefore like to acknowledge the discussions undertaken with and help provided by Mr. D. Young of the CANMET Cape Breton Coal Research Laboratory in converting the original North Star program for use on the IBM-AT.

REFERENCES

1. Zaporozec, A. 'Graphical interpretation of water quality data'; Ground Water; Vol. 10, No. 2, pp 32-43; 1972.
2. Young, D.A. and Aston, T.R.C. "'DUROV PLOT' users guide: Computer calculation and plotting of Durov diagrams for water chemistry analysis"; Division Report ERP/CRL 85-78(TR); CANMET, Energy, Mines and Resources Canada; 1985.

DUROV PLOT DATA LINES

ID#	DATE	Na	K	Ca	Mg	ALKAL	SO4	Cl
1	830322	90	3.4	93	14	76	32	275
2	830330	81	3	89	13	76	32	256
3	830415	61	2.7	79	11	77	28	196
4	830427	65	2.8	81	12	76	30	213
5	830429	67	2.8	74	10	76	27	180
6	830512	65	2.7	72	10	77	25	175
7	830526	60	2.4	74	10	78	23	180
8	830609	57	2.4	72	10	80	22	174
9	830623	57	2.6	73	10	87	19	174
10	830706	77	2.7	88	14	92	17	245
11	830712	93	3.2	93	15	93	15	275
12	830727	82	3.1	83	12	96	19	220
13	830811	66	2.8	80	13	99	19	202
14	830825	63	2.9	77	11	97	21	185
15	831003	73	3	78	12	93	18	212
16	831019	97	3.4	97	15	91	20	298
17	831026	111	3.7	101	16	88	20	340
18	831101	122	3.9	105	17	87	21	355

Table 1 - Input data file used for 'DUROV PLOT'

PERCENT ION CONCENTRATION

ID#	%NA	%Ca	%Mg	$\%HCO_3$	$\%SO_4$	%Cl
1	46.61	46.41	6.99	19.84	8.36	71.80
2	45.16	47.85	6.99	20.88	8.79	70.33
3	41.44	51.40	7.16	25.58	9.30	65.12
4	42.16	50.37	7.46	23.82	9.40	66.77
5	45.38	48.11	6.50	26.86	9.54	63.60
6	45.22	48.10	6.68	27.80	9.03	63.18
7	42.62	50.55	6.83	27.76	8.19	64.06
8	42.01	50.92	7.07	28.99	7.97	63.04
9	41.80	51.19	7.01	31.07	6.79	62.14
10	43.86	48.43	7.71	25.99	4.80	69.21
11	47.11	45.54	7.35	24.28	3.92	71.80
12	47.25	46.09	6.66	28.66	5.67	65.67
13	42.52	49.44	8.03	30.94	5.94	63.13
14	42.82	50.03	7.15	32.01	6.93	61.06
15	45.78	46.99	7.23	28.79	5.57	65.63
16	47.27	45.67	7.06	22.25	4.89	72.86
17	49.50	43.59	6.91	19.64	4.46	75.89
18	50.79	42.36	6.86	18.79	4.54	76.67

Table 2 - Tabulated percentage ion concentrations

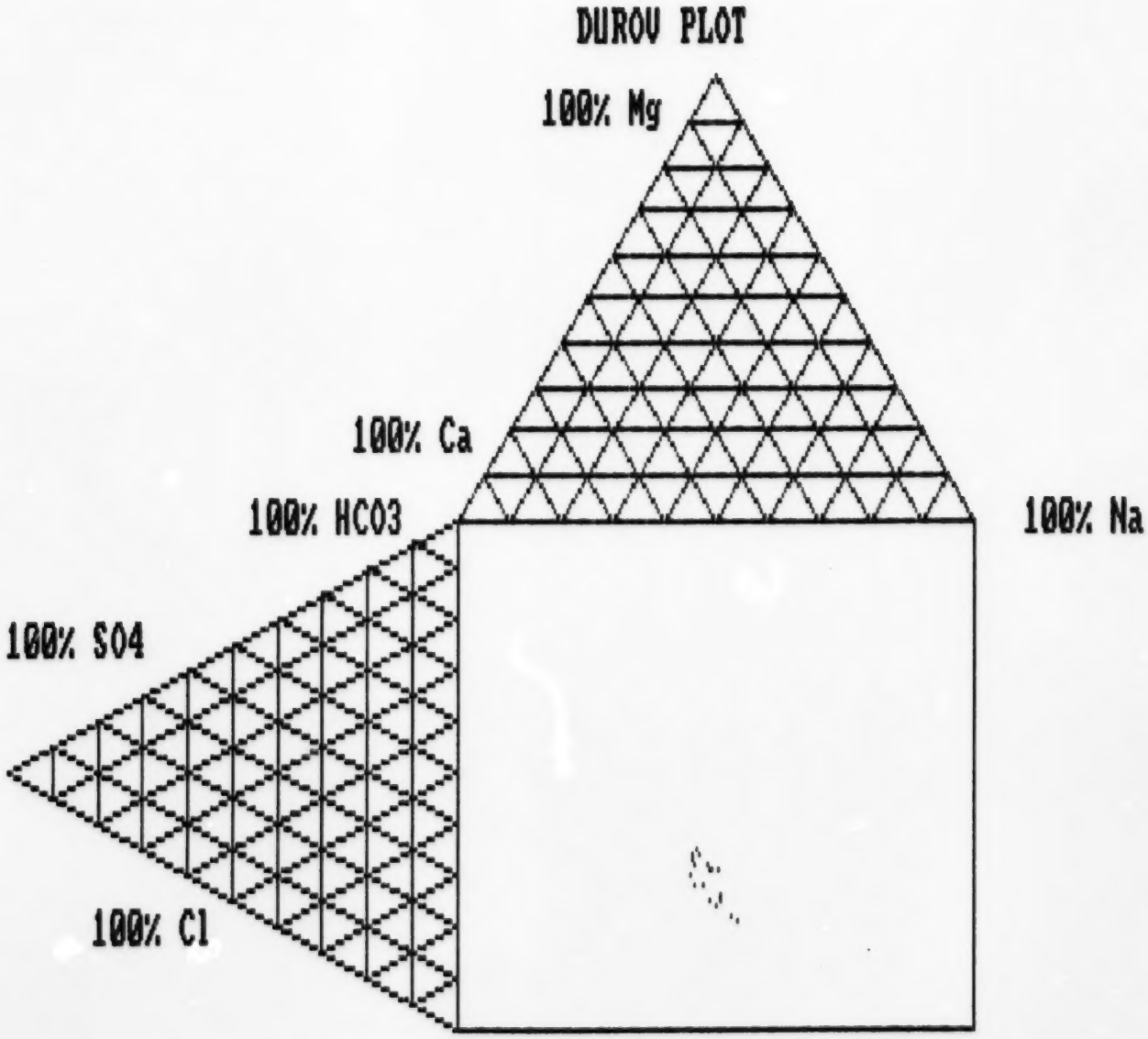

Figure 1 - 'DUROV PLOT' showing data given in Table 1 and printed using the EPSON FX100

Figure 2 - 'DUROV PLOT' enlargement option showing data given in Table 1 and printed using the EPSON FX100

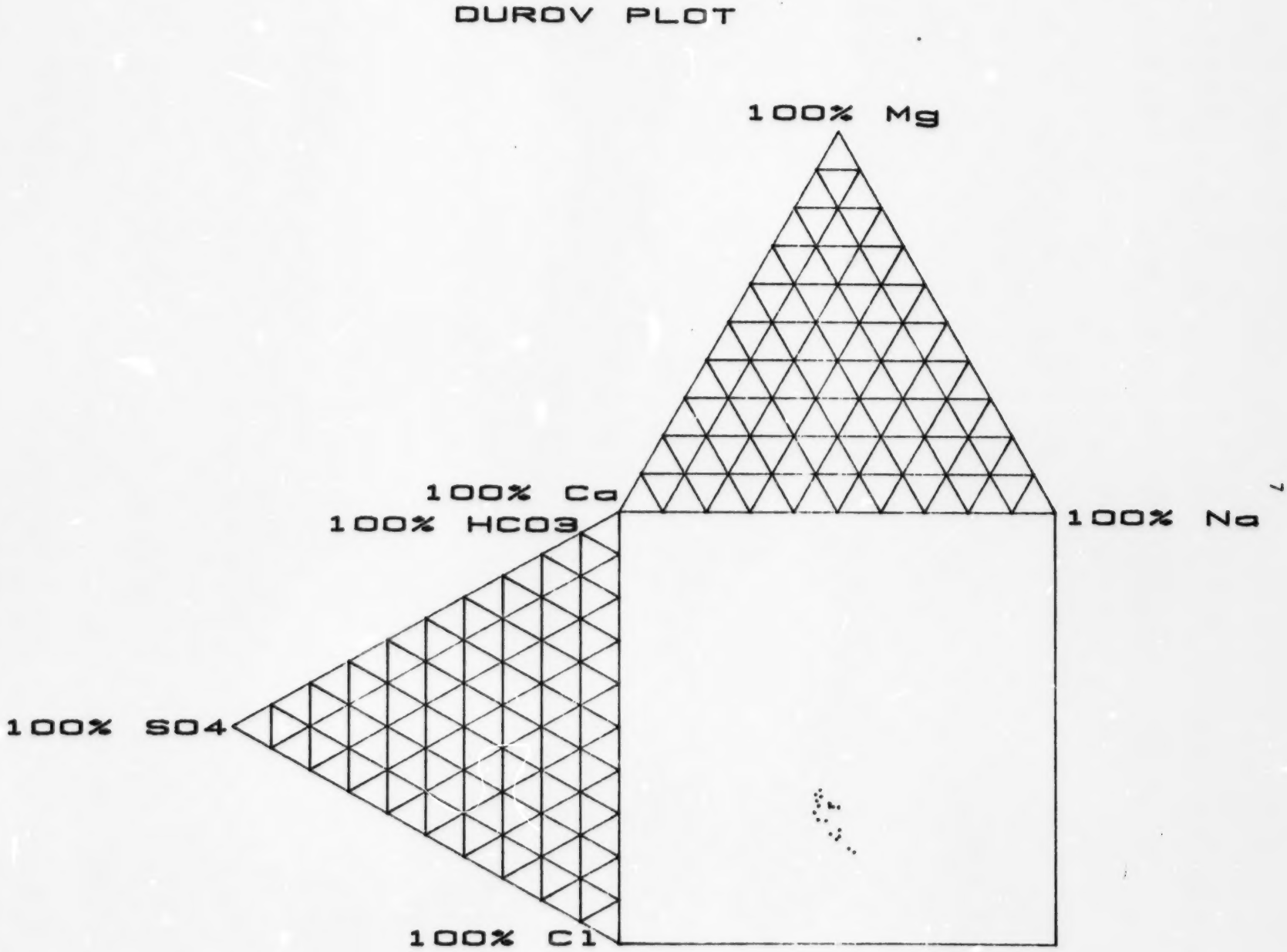

Figure 3 - 'DUROV PLOT' showing data given in Table 1 and plotted using the TAXAN plotter

APPENDIX A

```
100 REM * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
110 REM *                                                                                             *
120 REM *  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  *
130 REM *  *                                                                                       *  *
140 REM *  *                  DUROV  PLOT  PROGRAM                                                 *  *
150 REM *  *                  ---------------------                                                *  *
160 REM *  *                                                                                       *  *
170 REM *  *   Rewritten by   Derrick  Zinck                                                       *  *
180 REM *  *   Original  by   Dave  Young                                                          *  *
190 REM *  *                  Department of Energy, Mines & Resources                              *  *
200 REM *  *                  CANMET/CRL Cape Breton                                               *  *
210 REM *  *                  210  George St.                                                      *  *
220 REM *  *                  Sydney, N.S.                                                         *  *
230 REM *  *                  Canada  B1P 1J3                                                      *  *
240 REM *  *                                                                                       *  *
250 REM *  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  *
260 REM *                                                                                             *
270 REM * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
280 SCREEN 0,1,0,0: KEY OFF : ON ERROR GOTO 3580
290 CLS: LOCATE 5,10:INPUT" Do you want a description";A$
300 IF LEFT$(A$,1) = "Y" OR LEFT$(A$,1)="y" THEN 310 ELSE 680
310 CLS:PRINT:PRINT SPC(29) "PROGRAM DECRIPTION"
320 PRINT SPC(28) "-------------------"
330 PRINT"    Input parameters -       The source file of Hydro-Chemical data is
"
340 PRINT"                      the most important parameter to be input by the
"
350 PRINT"                      user."
360 PRINT"                           All other input  parameters are explained
"
370 PRINT"                      through the use of service menus.":PRINT
380  PRINT"    File description -       The Hydro-Chemical  data table  is of th
e"
390 PRINT"                      following strusture:":PRINT
400 PRINT"       ID#    Date    Na    K    Ca    Mg    Alkal    SO4    Cl":PRINT
:PRINT:PRINT
410 GOSUB 3640
420 PRINT"    Modes of operation -"
430     PRINT"                          (1)  Search by Colum Deliminators"
440     PRINT"                          (2)  Selective Search":PRINT:PRINT
450 PRINT SPC(23) "1)  Search by Colum Deliminator"
460 PRINT SPC(22) "-------------------------------":PRINT
470 PRINT"    This mode selectes lines of data to be plotted by supplying argume
nts"
480 PRINT" with the use of numeric deliminators.   As many as nine arguments can
 be
490 PRINT" set at once, in any particular format.
500 PRINT:PRINT"  example:    Select a two colum search."
```

```
510 PRINT"                  Column Date between 820001 and 830001"
520 PRINT"                  Column  Ci  between 100meg and 200meg":PRINT
530 PRINT" The program will read a line of data, if the first  argument  holds t
rue
540 PRINT" for the information stored under DATE then the program continues  to
the"
550 PRINT" to the next argument. If the line passes all arguments then it is sto
red"
560 PRINT" for  future use, else the line is proven false and it is rejected.  T
his"
570 PRINT" process is carried out for each line of data in the file."
580  GOSUB 3640
590 LOCATE 2:PRINT SPC(28) "(2) Selective Search"
600 PRINT SPC(27) "----------------------":PRINT
610 PRINT"    The user supplies the data line record to be processed.  It lets t
ne"
620 PRINT" user view the plotting in a graphical hybrid mode."
630 LOCATE 11:PRINT SPC(30) "Service Menu"
640 PRINT SPC(29) "--------------":PRINT
650 PRINT"    In general it allows a full screen DUROV plot, an enlargement of t
ne"
660 PRINT" plot,a hardcopy of the DUROV plot and the percent  ion  concentration
s."
670 GOSUB 3640
680 REM

             DIMENSION ARRAYS
690 DIM F(70),F1(70),F2(70),F3(70),F4(70),F5(70)
700 DIM A(70), B(70), C(70), D(70), E(70), F(70), G(70), H(70), K(70), W(70), W1
(70)
710 REM

                MAIN BODY
720 A(1)=0 : FLAG = 0
730 CLS:LOCATE 5,10 : INPUT"Please enter data filename and disk drive ";B$
740 IF B$="" THEN 730
750 GOSUB 3370 : CLOSE
760 CLS:LOCATE 5,12 : PRINT"There are ";D5;" entries in the data file ";B$;"":
 GOSUB 3640
770 IF D5 = 0 THEN 780 ELSE 800
780 PRINT:PRINT"This file is empty!"
790 PRINT"--------------------": FOR I = 1 TO 3000 : NEXT I: GOTO 710
800 CLS:LOCATE 2:PRINT"********************************** MAIN MENU ************
************************"
810 PRINT"  1).....................SEARCH DATA BY LIMITS"
820 PRINT"  2).....................POINT BY RECORD NO. PLOT"
830 PRINT"  3).....................ANOTHER  DATA  FILE"
840 PRINT"  4).....................CHAIN  TO  EDITOR"
```

```
850 PRINT"  5>.....END  SESSION"
860 PRINT"  6>.....SERVICE  MENU"
870 PRINT:PRINT"**********************************************************************
**********"
880 PRINT:PRINT SPC(50):INPUT"CHOICE ";Q
890 IF Q=1 THEN 1870 : Z6=0
900 IF Q=2 THEN 970  ELSE 910
910 IF Q=3 THEN 920 ELSE 930
920 GOTO 710
930 IF Q=4 THEN 940 ELSE 950
940 CHAIN "EDIT1"
950 IF Q=5 THEN 960 ELSE  IF Q=6 THEN 990 ELSE 800
960 END
970 GOSUB 2900
980 GOTO 800
990 SCREEN 0,1,0,0: CLS:LOCATE 2
1000 PRINT"********************************* SERVICE LISTING ********************
***********"
1010 PRINT"  1>.....BURDV  PLOT"
1020 PRINT"  2>.....DATA  LINES"
1030 PRINT"  3>.....PLOT  ENLARGEMENT"
1040 PRINT"  4>.....PERCENT ION CONCENTRATION"
1050 PRINT"  5>.....MAIN  MENU"
1060 PRINT"  6>.....LOAD ALL FILE DATA TO BUFFER" : PRINT"  7>...
.....CLEAR BUFFER": PRINT"  8>.....BURDv PLOT ON PLOT
TER":PRINT
1070 PRINT"**********************************************************************
***********"
1080 PRINT:PRINT SPC(50):INPUT"CHOICE ";Q
1090 IF FLAG = 0 AND Q < 5 THEN PRINT:PRINT"Buffer is empty" ELSE 1110
1100 A$ = INKEY$: IF A$ = "" THEN 1100 ELSE GOTO 990
1110 IF Q= 1 THEN 1120 ELSE 1170
1120 GOSUB 3120
1130 FLAG=1
1140 GOSUB 1330 : GOSUB 1480 : GOSUB 1710 : IF I$= "Y" THEN  GOSUB 1690 : GOSUB
1810 ELSE GOSUB 1810
1150 REM
1160 A$=INKEY$: IF A$="" THEN 1160
1170 IF Q=2 THEN 1180 ELSE 1190
1180 GOSUB 2600
1190 IF Q=3 THEN 1200 ELSE 1240
1200 GOSUB 3120:SCREEN 2,,0,0
1210 VIEW (30,0)-(550,199) : WINDOW (86.60501,0)-(186.605,100):GOSUB 1380
1220 IF I$="Y" THEN GOSUB 1690 : GOSUB 1810  ELSE GOSUB 1810
1230 A$=INKEY$: IF A$="" THEN 1230
1240 IF Q=4 THEN 1250 ELSE 1260
1250 GOSUB 3260 : GOSUB 3190
1260 IF Q=5 THEN 1310
```

```
1270 IF Q = 6 THEN GOSUB 3470 : GOSUB 2360 : GOTO 990
1280 IF Q = 7 THEN FLAG = 0 : Z=0 : Z9=0:PRINT:PRINT"Buffer has been cleared."EL
SE 1300
1290 A$=INKEY$:IF A$="" THEN 1290 ELSE 1300
1300 IF Q=6 AND FLAG=1 THEN GOSUB 3340 ELSE 990
1310 CLOSE : GOTO 800
1320 GOTO 990
1330 REM

              SUBROUTINE FOR THE DUROV PLOT
1340 CLS
1350 SCREEN 2,,0,0
1360  VIEW (0,0)-(480,199)
1370 WINDOW (0,0)-(200,200)
1380 LINE (0,50)-(86.60501,100)
1390 LINE (86.60501,100)-(136.605,186.605):LINE (136.605,186.605)-(186.605,100)
1400 LINE (86.60501,100)-(86.60501,0)
1410 LINE (86.60501,0)-(0,50)
1420 LINE (186.605,0)-(186.603,100)
1430 LINE (86.60501,0)-(186.605,0)
1440 LINE (86.60501,100)-(186.605,100)
1450 RETURN
1460 REM

                FILL DUROV TRIANGLE
1470 REM
1480 J=0
1490 FOR I= 10 TO 100 STEP 10
1500 J=J+1
1510 X1=.86605 * I : Y1 = .5773 * X1 +50 :X(J) = X1 :Y(J) = Y1
1520 X2=86.60501 : Y2=100 - I :X1(J) = X2: Y1(J)=Y2
1530 X3=86.60501 - I*.86605: Y3=50-.5773*X3: X2(J)=X3: Y2(J)= Y3
1540 X4=186.605-I: Y4 =100 : X3(J)= X4: Y3(J)=Y4
1550 X5=86.60501+I*.5: Y5= 100+.86605*I: X4(J)=X5: Y4(J)=Y5
1560 X6=136.605+I*.5: Y6=186.605-.86605*I: X5(J)=X6: Y5(J)=Y6
1570 NEXT
1580 FOR I = 1 TO 9
1590 LINE (X(I),Y(I))-(X1(10-I),Y1(10-I))
1600 LINE (X1(10-I),Y1(10-I))-(X2(I),Y2(I))
1610 LINE (X(I),Y(I))-(X2(10-I),Y2(10-I))
1620 LINE (X3(I),Y3(I))-(X5(10-I),Y5(10-I))
1630 LINE (X5(10-I),Y5(10-I))-(X4(I),Y4(I))
1640 LINE (X3(I),Y3(I))-(X4(10-I),Y4(10-I))
1650 NEXT
1660 RETURN
1670 REM

                        SECTIONS PLOT
```

```
1680 REM
1690 LINE (136.605,0)-(136.605,100) : LINE (86.60501,50)-(186.605,50)
1700 RETURN
1710 REM

                    LABEL  AXIS
1720 REM
1730 LOCATE 1,34 :PRINT"DUROV PLOT"
1740 LOCATE 3,32 :PRINT"100% Mg"
1750 LOCATE 13,60 :PRINT"100% Na"
1760 LOCATE 16 :PRINT"100% SO4"
1770 LOCATE 23,6 :PRINT"100% Cl"
1780 LOCATE 11,21 :PRINT"100% Ca"
1790 LOCATE 13,15 :PRINT"100% HCO3"
1800 RETURN
1810 REM

          SUBROUTINE FOR PLOTTING DUROV POINTS
1820 REM
1830 FOR X=1 TO Z
1840 PSET(#1(X),W(X))
1850 NEXT
1860 RETURN
1870 REM

          SEARCH  DATA  SECTION
1880 REM
1890 CLS
1900 LOCATE 2,4 :PRINT"You are in the search data section of the program"
1910  LOCATE 3,3 :PRINT"-------------------------------------------------"
1920 FOR I = 1 TO 2000 : NEXT
1930 CLS
1940 LOCATE 2,4 :INPUT "By how many columns do you wish to search ";N
1950 REM
        Checks for an out of bounds column
1960 REM
1970 N9=N : GOSUB 3460 : IF A$="N" THEN 1980 ELSE 2000
1980 PRINT"You have entered an out of bounds column number!"
1990 PRINT"-----------------------------------------------
2000 CLS
2010 PRINT"Input the order in which the search is to be conducted "
2020 RESTORE 3330
2030     FOR I = 1 TO 9
2040 READ V$,V : PRINT V," " ,V$
2050     NEXT
2060     FOR I = 1 TO N
2070 PRINT
2080 INPUT"Enter the columns to search ",X(I)
```

```
2090 N9 = X(I):GOSUB 3460: IF A$="N"  THEN 2100 ELSE 2120
2100 PRINT"You inputted an out of bounds column number "
2110 PRINT"-----------------------------------------":GOTO 2080
2120 INPUT "Enter the lower numeric limit for the search ";V(X(I))
2130 INPUT"Enter the upper numeric limit for the search ";V1(X(I))
2140   NEXT
2150 CLS:PRINT SPC(30) "Search in process...."
2160 CLOSE : OPEN "i", #1,B$: Z=0
2170 IF EOF(1) THEN 2180 ELSE 2190
2180  GOSUB 2370:GOTO 990
2190 INPUT #1,A,B,C,D,E,F,G,H,K
2200 FOR I = 1 TO N
2210 Y=A: IF X(I) = 1 THEN GOSUB 2330
2220 Y=B: IF X(I) = 2 THEN GOSUB 2330
2230 Y=C: IF X(I) = 3 THEN GOSUB 2330
2240 Y=D: IF X(I) = 4 THEN GOSUB 2330
2250 Y=E: IF X(I) = 5 THEN GOSUB 2330
2260 Y=F: IF X(I) = 6 THEN GOSUB 2330
2270 Y=G: IF X(I) = 7 THEN GOSUB 2330
2280 Y=H: IF X(I) = 8 THEN GOSUB 2330
2290 Y=K: IF X(I) = 9 THEN GOSUB 2330
2300  NEXT
2310 GOTO 2340
2320 REM

            THIS SECTION SOLVES THE SEARCH ARGUMENT
2330 IF Y< V(X(I)) OR Y> V1(X(I)) THEN 2170 ELSE RETURN
2340 Z=Z+1 : Z9=1
2350 A(Z)=A : B(Z)=B : C(Z)=C : D(Z)=D : E(Z)=E : F(Z)=F : G(Z)=G :H(Z)=H : K(Z)
=K : GOTO 2170
2360 REM
2370 REM

            THIS SECTION  CALCULATES % AND DUROV POINTS
2380 REM
2390   FOR X=Z9 TO Z
2400    T=C(X) + D(X) + E(X) + F(X)
2410 IF T=0 THEN RETURN
2420 P(X)=((C(X) + D(X))/T)*100
2430 P1(X) =(E(X)/T) * 100
2440 P2(X) =(F(X)/T) * 100
2450 T= G(X) + H(X) + K(X)
2460 P3(X)= (G(X)/T) * 100
2470 P4(X)=(H(X)/T) * 100
2480 P5(X)= (K(X)/T) * 100
2490 L4=86.60501-P4(X) * .86605 : L5=50 - .5773 * L4
2500 L8=86.60501+P2(X) * .5 :L9 = 100 + .86605 * P2(X)
2510 W1(X) = (L9 + 50 + (1.732 * P(X))) / 1.732
```

```
2520 W(X) = .5773 * L4+(50-P5(X))
2530   NEXT
2540 IF Q=1 THEN 2550 ELSE 2560
2550 CLOSE
2560 FLAG = 1 :RETURN
2570 CLOSE : GOTO 990
2580 GOSUB 1330
2590 REM
2600 REM

                PRINTS DATA LINES USED IN DUROV PLOT
2610 REM
2620 LPRINT CHR$(18);CHR$(27)"6";CHR$(14);SPC(6);CHR$(27)"-1";" DUROV  PLOT  DAT
A  LINES";CHR$(27)"H";CHR$(27)"-0"
2630 LPRINT: LPRINT: LPRINT
2640 WIDTH "LPT1:",132
2650 LPRINT CHR$(15);
2660 LPRINT CHR$(27);"D";CHR$(20);CHR$(30);CHR$(40);CHR$(50);CHR$(60);CHR$(70);C
HR$(80);CHR$(90);CHR$(100);CHR$(0)
2670 LPRINT CHR$(27)"-1";
2680 RESTORE 3330
2690    FOR X= 1 TO 9
2700 READ R$,V
2710 IF V=9 THEN 2740
2720 LPRINT CHR$(9);R$;
2730 GOTO 2750
2740 LPRINT CHR$(9);R$
2750    NEXT
2760 LPRINT CHR$(27)"-0";
2770 LPRINT CHR$(27);"D";CHR$(20);CHR$(28);CHR$(38);CHR$(48);CHR$(58);CHR$(68);C
HR$(80);CHR$(88);CHR$(98);CHR$(0)
2780 REM GOSUB 3300: CLOSE: OPEN "LPT1:" AS #1
2790      FOR X = 1 TO Z
2800 LPRINT CHR$(9);A(X);CHR$(9);B(X);CHR$(9);C(X);CHR$(9);D(X);CHR$(9);E(X);CHR
$(9);F(X);
2810 LPRINT CHR$(9);G(X);CHR$(9);H(X);CHR$(9);K(X)
2820 IF X = Z THEN 2830 ELSE 2840
2830 LPRINT CHR$(27);"-";CHR$(1);
2840      NEXT
2850 LPRINT "":LPRINT " "
2860 LPRINT CHR$(27);"-";CHR$(0)
2870 LPRINT CHR$(12)
2880 RETURN
2890 END
2900 CLOSE : OPEN "I",#1,B$
2910 GOSUB 1350 :GOSUB 1460 : GOSUB 1710
2920 REM
2930 REM
```

```
                    POINT BY RECORD PLOT
2940 REM
2950 Z=0
2960 REM
2970 LOCATE 1,1:FOR Y=1 TO 78:PRINT" ";:NEXT Y:LOCATE 1,1:INPUT "Enter record nu
mber to plot. (cr) for menu ";F$
2980 IF LEN (F$)=0 THEN 3080  ELSE D=VAL(F$)
2990 IF INT(D)<1 OR INT(D) >D5 THEN 3000 ELSE 3030
3000 LOCATE 1,1 : FOR Y=1 TO 79 :PRINT" ";:NEXT Y :LOCATE 1,1: PRINT"You entered
 an out of bounds row number."
3010 A$=INKEY$: IF A$="" THEN 3010
3020 GOTO 2960
3030 Z=Z+1 : Z9=Z
3040 CLOSE : OPEN "I",#1,B$
3050 FOR D=1 TO D : INPUT #1,A(Z),B(Z),C(Z),D(Z),E(Z),F(Z),G(Z),H(Z),K(Z):NEXT D

3060 GOSUB 2390:PSET(W1(Z),W(Z))
3070 GOTO 2960
3080 CLOSE: SCREEN 0,1,0,0
3090 GOTO 990
3100 REM

            ASKS IF YOU WANT THE PLOT SECTIONED
3110 REM
3120 LOCATE 1,1: INPUT "Do you want the plot sectioned ";I$
3130 REM
3140 LOCATE 1,1:PRINT"If you would like a hardcopy of the DUROV PLOT then press
shift PrtSc"
3150 A$=INKEY$:IF A$="" THEN 3150
3160 RETURN
3170 REM

             PRINTS PERCENT ION CONCENTRATION
3180 REM
3190  CLOSE: OPEN "lpt1:" AS #1 : FOR X= 1 TO Z
3200 LPRINT TAB(22);A(X),: LPRINT USING "###.##         ";  P(X),P1(X),P2(X),P3(
X),P4(X),P5(X)
3210 NEXT
3220 LPRINT CHR$(12)
3230 RETURN
3240 REM

             PRINTS HEADLINES FOR PERCENT ION CONCENTRATIONS
3250 REM
3260 CLOSE
3270 LPRINT CHR$(18);CHR$(27)"E";CHR$(14);SPC(5);CHR$(27)"-1";" PERCENT  ION  CO
NCENTRATION";CHR$(27)"H";CHR$(27)"-0"
```

```
3280 LPRINT:LPRINT:LPRINT
3290 WIDTH "LPT1:",132
3300 LPRINT SPC(12);CHR$(27)"-1";
3310 LPRINT CHR$(15);" ID#";SPC(7);"%NA";SPC(13);"%Ca";SPC(12);"%Mg"SPC(11);"%HC
O";CHR$(27)"S1";"3";CHR$(27)"T";SPC(10);"%SO";CHR$(27)"S1";"4";CHR$(27);"T";SPC(
11);"%Cl";CHR$(27)"-0":LPRINT
3320 RETURN
3330 DATA "ID#",1,"DATE",2,"Na",3,"K",4,"Ca",5,"Mg",6,"ALKAL",7,"SO4",8,"Cl",9
3340 REM
3350 REM

               COUNTS NUMBER OF LINES IN THE FILE
3360 REM
3370 CLOSE: OPEN B$ FOR INPUT AS #1
3380 D5=0
3390 REM
3400 IF EOF(1) THEN RETURN
3410 INPUT#1,A,B,C,D,E,F,G,H,K
3420 D5=D5+1
3430 GOTO 3400
3440 REM

            ROUTINE TO CHECK FOR AN OUT OF BOUNDS COL #
3450 REM
3460 IF INT (N9)<1 OR INT(N9)>9 THEN A$="N" :RETURN
3470 CLOSE
3480 OPEN "I",#1,B$
3490 Z=0:X=0
3500 IF EOF(1) THEN Z=X:Z9=1:RETURN
3510 X=X+1
3520 INPUT #1,A(X),B(X),C(X),D(X),E(X),F(X),G(X),H(X),K(X)
3530 GOTO 3500
3540 REM

         TAXAN PLOTTER ROUTINE
3550 REM
3560 CHAIN "TAXAN.BAS",10,ALL
3570 RETURN
3580 REM

          Error Routine
3590 REM
3600 IF ERR = 53 THEN PRINT" File not found. Please try again....": GOTO 3610 EL
SE 3630
3610 PRINT:INPUT " Enter file name and disk drive";B$
3620 IF B$="" THEN 3610
3630 RESUME
3640 REM
```

```
        PRESS KEY ROUTINE
3650 REM
3660 LOCATE 23:PRINT SPC(26) "(press any key to continue)"
3670 FOR X=1 TO 1000 :NEXT X
3680 LOCATE 23 :PRINT SPC(26) "(press any     to continue)"
3690 V$=INKEY$: IF V$="" THEN 3660 ELSE CLS:RETURN
```

APPENDIX B

```
10 REM*************************************************************************
20 REM***                                                                   ***
30 REM***                  TAXAN  PLOTTER  ROUTINE                          ***
40 REM***                                                                   ***
50 REM***              written by:     Derrick Zinck                        ***
60 REM***                              January 1986.                        ***
70 REM***                                                                   ***
80 REM***          Department of Energy Mines & Resources                   ***
90 REM***          CANMET/CRL  Cape Breton                                  ***
100 REM**          210 George St.                                           ***
110 REM**          Sydney,   Nova Scotia                                    ***
120 REM**          Canada    B1P 1J3                                        ***
130 REM**                                                                   ***
140 REM*************************************************************************
150 REM

                   This Program Works in Conjunction with
160 REM            the Durov Plot program to produce plots
170 REM            on the Taxan 710 x-y plotter.
180 REM
190  CLOSE : OPEN "COM1:300,N,8,1,CS,DS" AS #1
200 EN=2
210 T$=CHR$(3)
220 CLS:LOCATE 2,25 :PRINT "TAXAN PLOTTER ROUTINE"
230 PRINT:PRINT"       Insert paper into plotter and press any key to start plot
."
240 A$=INKEY$: IF A$="" THEN 240 ELSE 250
250 Z=136 : X=190
260 CLS: LOCATE 10,20:PRINT" Plotting in progress. Please wait....."
270 x=190
280 PRINT #1,"IN"
290 PRINT #1,"SC 0,608,0,400"
300 PRINT #1,"CS" 0
310 PRINT #1,"SS"
320 P=2
330 PRINT #1,"SP" P
340 PRINT #1,"PA" X;0
350 PRINT #1,"PD" X;0
360 PRINT #1,"PD" X+Z;0
370 PRINT #1,"PD" X+Z;Z
380 PRINT #1,"PD" X;Z
390 PRINT #1,"PD" X;0
400 PRINT #1,"PU"
410 REM

         DRAWS TOP TRIANGLE
420 REM
430 PRINT #1,"PA"X+Z;Z
```

```
440 PRINT #1,"PD"
450 PRINT #1,"PD" X+Z/2;Z+120
460 PRINT #1,"PD" X;Z
470 REM

          DRAWS SIDE TRIANGLE

480 REM
490 PRINT #1,"PD" X-120;Z/2
500 PRINT #1,"PD" X;0
510 PRINT #1,"PU"
520 REM
530 J=X : K= X+Z : L=L/10 : L=L/2
540 FOR I=148 TO 244 STEP 12
550   J=J+6.8 : K=K-6.8
560 PRINT #1,"PA" J;I
570 PRINT #1,"PD"
580 PRINT #1,"PD" K;I
590 PRINT #1,"PU"
600 NEXT
610 REM

          DRAW TOP

620 REM
630 L=0 : J=256 : K=K-6.8
640 FOR I=244 TO 148 STEP -12
650  L=L+13.6: J=J-12 :K=K+6.8
660 PRINT #1,"PA" K;I
670 PRINT #1,"PD" X+L;Z
680 PRINT #1,"PU"
690 NEXT
700 REM
710 L=136: K=68 +X
720 FOR I=244 TO 148 STEP -12
730 L=L-13.6 : K=K-6.8
740 PRINT #1,"PA" K;I
750 PRINT #1,"PD" X+L;Z
760 PRINT #1,"PU"
770 NEXT
780 REM

               DRAW SIDE TRIANGLES

790 REM
800 K=X : L=Z
810 FOR I = 129.2 TO 68 STEP -6.8
820 K=K-12 : L= L-13.6
830 PRINT #1,"PA" K;I
840 PRINT #1,"PD" X;L
850 PRINT #1,"PU"
```

```
860 NEXT
870 REM
880 REM
890 REM
900 K=X : L=0
910 FOR I = 129.2 TO 68 STEP -6.8
920 K=K-12 : L=L+6.8
930 PRINT #1,"PA" K;I
940 PRINT #1,"PD" K;L
950 PRINT #1,"PU"
960 NEXT
970 REM
980 REM
990 REM
1000 K=X : L=0
1010 FOR I = 6.8 TO 61.2 STEP 6.8
1020 K=K-12 :L=L+13.6
1030 PRINT #1,"PA" K;I
1040 PRINT #1,"PD" X;L
1050 PRINT #1,"PU"
1060 NEXT
1070 PRINT #1,"SP" 4:FOR X=1 TO 7
1080 READ ST$,D,E
1090 PRINT#1,"PU","PA" D:E;"SR" 1.1;"VS" 1
1100 PRINT#1,"LB"ST$ T$
1110 NEXT
1120 RESTORE
1130 REM

             PLOT POINTS

1140 REM
1150 FOR I = 1 TO EN
1160 X=W(I) * 1.36 :  Y = ( W1(I) - 86.60501) * 1.36 + 190
1170 PRINT #1, "sp" 1
1180 PRINT #1,"PA" Y,X
1190 PRINT #1,"PD"
1200 PRINT #1,"PU"
1210 NEXT
1220 CLOSE
1230 Z=EN
1240 CLS: LOCATE 13,20 :PRINT" Press any key to return to DUROV program."
1250 A$= INKEY$: IF A$= "" THEN 1250
1260 CLOSE
1270 CHAIN"DUROV.BAS",910,ALL
1280 DATA DUROV PLOT,140,290,100% Mg,230,260,100% Ca,130,140
1290 DATA 100% HCO3,100,130,100% SO4,0,66,100% Cl,125.0,100% Na,330,133
```

APPENDIX C

```
10 REM*************************************************************************
20 REM******         DUROV PLOT DATA EDITOR                                  ******
30 REM******              Programmed by     Derrick D.Zinck                  ******
40 REM******                                CO-OP Student                    ******
50 REM******                                January  1986                    ******
60 REM******                                                                 ******
70 REM******         Cape Breton Coal Reasearch Laboratory                   ******
80 REM******         210 George St., Sydney, Nova Scotia.                    ******
90 REM*************************************************************************
100 CLOSE
110 ON ERROR GOTO 1380
120 DIM A(70),B(70),C(70),D(70),E(70),F(70),G(70),H(70),K(70)
130 KEY OFF
140 CLS:LOCATE 2
150 PRINT"************************************ EDITOR ************************
**********":PRINT
160 PRINT"        (1).................Create a new data file":PRINT
170 PRINT"        (2).................Load an existing file":PRINT
180 PRINT"        (3).................Return to DUROV PLOT":PRINT
190 PRINT"        (4).................Quit":PRINT
200 PRINT"        (5).................Delete a file":PRINT
210 PRINT"*************************************************************************
**********"
220 LOCATE 17,45:INPUT"Choice: ";Q
230 IF Q = 1 THEN GOSUB 940 : B$=A$ :GOTO 320
240 IF Q = 2 THEN 260
250 IF Q = 3 THEN 1170
260 IF Q = 4 THEN 1310
270 IF Q = 5 THEN GOSUB 1450 : GOTO 140 ELSE 140
280 N=15
290 INPUT "Enter file name and disk drive ";B$
300 IF B$="" THEN 290 ELSE 310
310 CLOSE: OPEN "i",#1,B$
320 CLS:LOCATE 2 :PRINT"     ***************************** EDIT SECTION *********
**********************"
330 PRINT"              (1).............Edit Data":PRINT
340 PRINT"              (2).............Add New Data":PRINT
350 PRINT"              (3).............Main Menu":PRINT
360 PRINT"     ***************************************************************
**********"
370 PRINT:PRINT SPC(50);: INPUT "Choice: ";Q
380 IF Q = 1 THEN 410
390 IF Q = 2 THEN 1190
400 IF Q = 3 THEN 140 ELSE 320
410 GOSUB 1020 : GOSUB 1090
420 INPUT"    From which line number do you wish to observe ";X
430 IF X=0 THEN 320
```

```
440 IF INT(X) < 1 OR INT(X) > 7 THEN 450 ELSE 460
450 PRINT" You entered an out of range file. ": GOTO 420
460 OPEN "I",#1,B$
470 FOR Q=1 TO X-1: INPUT #1,A,B,C,D,E,F,G,H,K : NEXT
480 N=X+15
490 GOSUB 1320
500 T=(X-1)*45
510 IF EOF(1) THEN 520 ELSE 530
520  GOSUB 620 :CLOSE : GOSUB 1000 : GOTO 320
530 INPUT#1,A,B,C,D,E,F,G,H,K
540  LOCATE ,5 :PRINT A;: LOCATE ,12:PRINT B;: LOCATE ,22: PRINT C;: LOCATE  ,32
 : PRINT D;: LOCATE  ,40 : PRINT E;: LOCATE  ,49 : PRINT F;: LOCATE  ,57 : PRINT
 G ;: LOCATE  ,67 : PRINT H;: LOCATE  ,75 : PRINT K
550 X=X+1:IF X=N THEN 560 ELSE 500
560 GOSUB 620
570 INPUT" Do you wish to continue observing";A$
580 IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 600 ELSE 590
590 CLOSE : GOSUB 1000: GOSUB 1140 : GOTO 320
600 GOSUB 1370
610 GOTO 500
620 REM

            EDIT DATA SECTION
630 REM
640 PRINT:GOSUB 1350:PRINT:INPUT"Do you wish to edit this data ";A$
650 N=N+15
660 IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)= "y" THEN 690 ELSE RETURN
670 INPUT "Do you wish to continue observing ";A$
680 IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)= "y" THEN RETURN ELSE 610
690 INPUT" From Row no. ";R : INPUT" To Row no. ";R1
700 INPUT" From Col.no. ";C : INPUT" To Col.no. ";C1
710 IF INT(R)<1 OR INT(R1) > 7 THEN 740
720 IF INT(C)<1 OR INT(C1) > 9 THEN 750
730 GOTO 840
740 PRINT"You entered an out of range row.": GOTO 690
750 PRINT"You entered an out of range col.": GOTO 690
760 FOR I= R TO R1
770 FOR J= C TO C1
780 T = (I-1) * 45 + (J-1) * 5
790 PRINT "Enter value for row ";I;" col. ";J ;
800 INPUT Z
810 IF J=1 THEN A(I)=Z ELSE IF J=2 THEN B(I)=Z:ELSE IF J=3 THEN C(I)=Z ELSE IF J
=4 THEN D(I)=Z ELSE IF J=5 THEN E(I)=Z ELSE IF J=6 THEN F(I)= Z ELSE IF J= 7 THE
N G(I)=Z ELSE IF J=8 THEN H(I)=Z ELSE IF J=9 THEN K(I) =Z ELSE GOTO 630
820 NEXT :NEXT
830 GOTO 900
840 CLOSE
850 X=0
```

```
860 OPEN "I",#1,B$
870 IF NOT EOF(1) THEN 880 ELSE 760
880 X=X+1
890 INPUT#1,A(X),B(X),C(X),D(X),E(X),F(X),G(X),H(X),K(X):GOTO 870
900  CLOSE: KILL B$ :OPEN "O",#1,B$
910 FOR Q= 1 TO X:WRITE#1,A(Q),B(Q),C(Q),D(Q),E(Q),F(Q),G(Q),H(Q),K(Q):NEXT Q
920 INPUT "Continue editing ";A$
930 IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 690 ELSE XI=1:RETURN
940 REM

            CREATE A NEW FILE
950 REM
960 INPUT "New file name: ";A$
970 OPEN "O",#1,A$
980 CLOSE
990 RETURN
1000 REM

              FINDS THE NUMBER OF LINES IN THE FILE
1010 REM
1020 CLOSE :OPEN "I",1,B$
1030 Z=0
1040 IF EOF(1) THEN 1060 ELSE 1050
1050 INPUT#1,A,B,C,D,E,F,G,H,K
1060 Z=Z+1
1070 GOTO 1040
1080 CLOSE: RETURN
1090 REM

            States number of columns in the file
1100 REM
1110 IF Z= 0 THEN PRINT"The file '";B$;"' is empty.":GOTO 1130
1120 PRINT"There is ";Z;" lines in the file ";B$
1130 RETURN
1140 REM

            This section writes an end mark in the file
1150 REM
1160 RETURN
1170 REM

            Chain to Durov Plot Program
1180 CHAIN "DUROV"
1190 GOSUB 1000:GOSUB 1090
1200 CLOSE : OPEN B$ FOR APPEND  AS 1
1210 T=Z*45
1220   FOR I= 1 TO 9
1230      READ R$,V
```

```
1240 PRINT"Enter data value ";R$;" row ";Z+1;" column ";V;: INPUT A
1250 WRITE#1,A
1260 T=T+5
1270 NEXT
1280 Z=Z+1 :RESTORE:INPUT"Continue adding ";A$: IF LEFT$(A$,1)="Y" OR LEFT$(A$,1
) ="y" THEN 1210 ELSE 1290
1290 CLOSE : GOTO 320
1300 DATA "ID#",1,"DATE",2,"Na",3,"K",4,"Ca",5,"Mg",6,"HCO3",7,"SO4",8,"Cl",9
1310 CLS:END
1320 CLS:LOCATE 2:PRINT"COL  1        2        3        4        5        6
   7        8        9"
1330 PRINT"-------------------------------------------------------------------
-----------"
1340 LOCATE 4,5: PRINT"ID#      DATE     %Na       %K       %Ca       %Mg      %HCO
3     %SO4     %CL"
1350 PRINT"-------------------------------------------------------------------
-----------"
1360 RETURN
1370 RETURN
1380 REM

             Error Routine
1390 REM
1400 IF ERR=53 THEN 1420 ELSE 1440
1410 IF ERR=55 THEN CLOSE: RESUME
1420 PRINT:PRINT"File not found error":INPUT "Enter file name and disk drive  ;B
$
1430 IF B$="" THEN 1420 ELSE 1440
1440 RESUME 290
1450 REM

           Delete a file
1460 ON ERROR GOTO 1560
1470 REM
1480 CLS
1490 LOCATE 2,10: INPUT "Do you want a directory ";Q$
1500 IF LEFT$(Q$,1)="Y" OR LEFT$(Q$,1)="y" THEN FILES
1510 INPUT"                    Enter file name to delete";Q$
1520 IF Q$="" THEN 1510
1530 IF Q$= "?"  THEN RETURN
1540 KILL Q$
1550 RETURN
1560 REM

               ERROR ROUTINE
1570 REM
1580 IF ERR = 53 OR ERR = 64 THEN PRINT" ERROR:  File not found":INPUT "Enter fi
le name to delete";Q$
1590 RESUME 1520
```